

Utilizing Biotic Soil for Landfill Closure

NC Erosion and Sediment
Control Design – Webinar
Series

Tuesday, November 10, 2020

Presented by: Kenton Yang, PE

SCS ENGINEERS

Agenda

- Case Study Overview
- Landfill Closure
- Design Drivers
- Soil Testing and Amendments
- Vegetation
- Erosion Control
- Results and Conclusions

Case Study – Initial Experience

- Landfill expansion - Piedmont
- Construction – protective cover
- Long interior slopes
- Weekly rain events



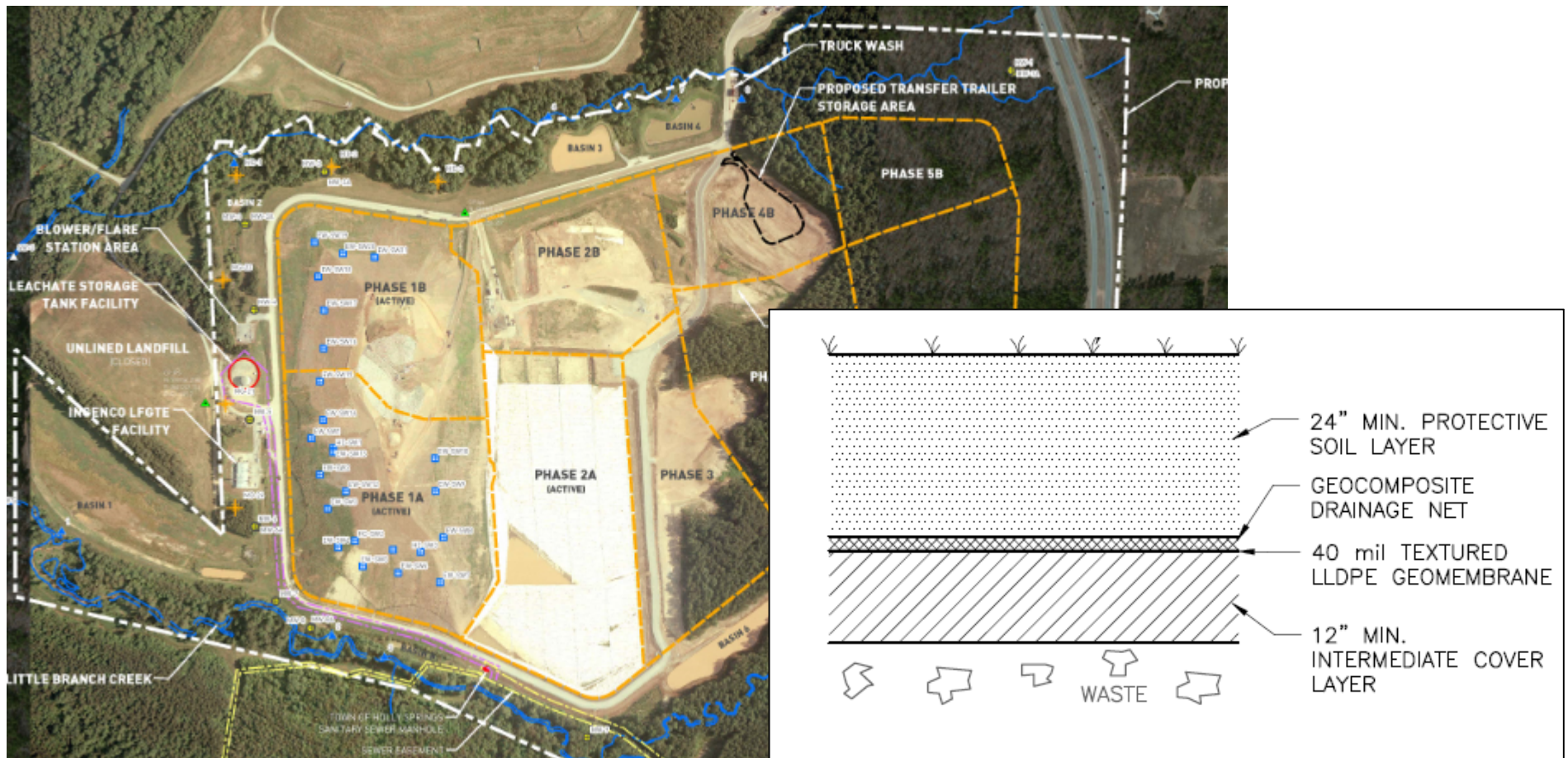






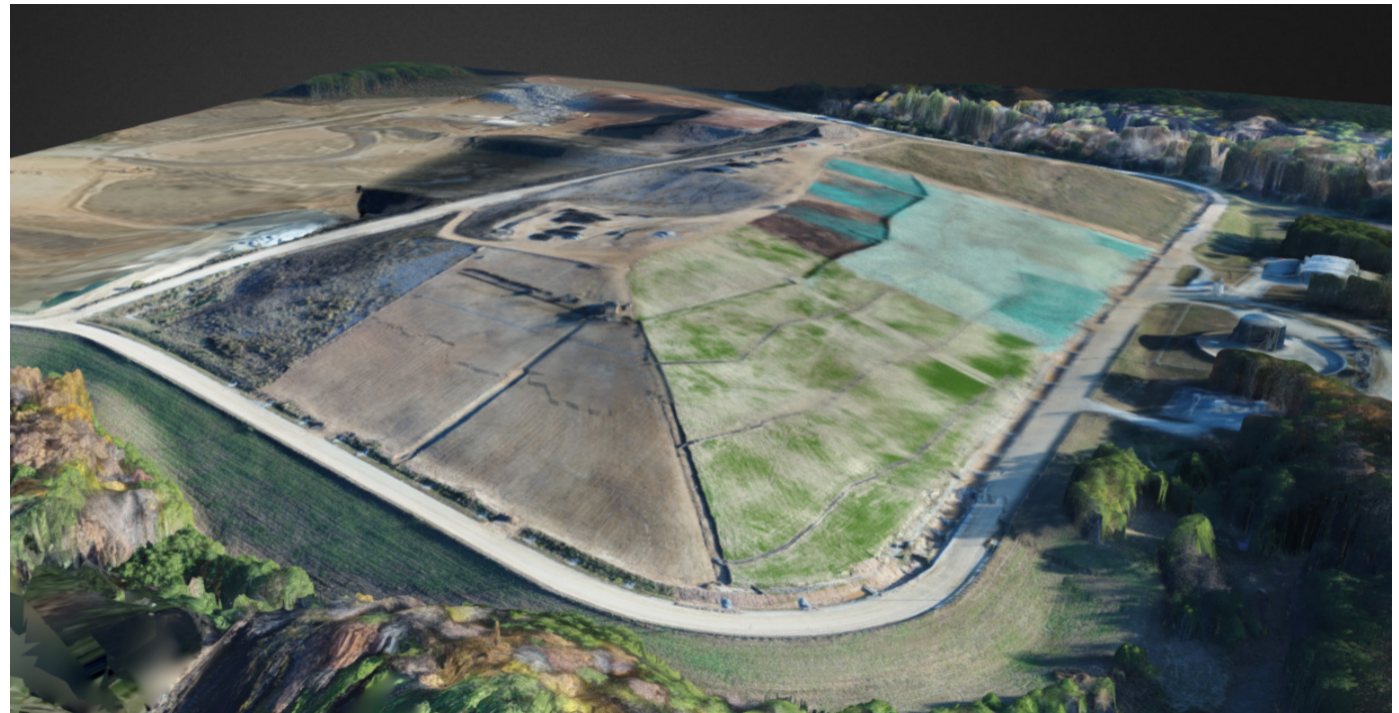


South Wake Landfill Closure Project

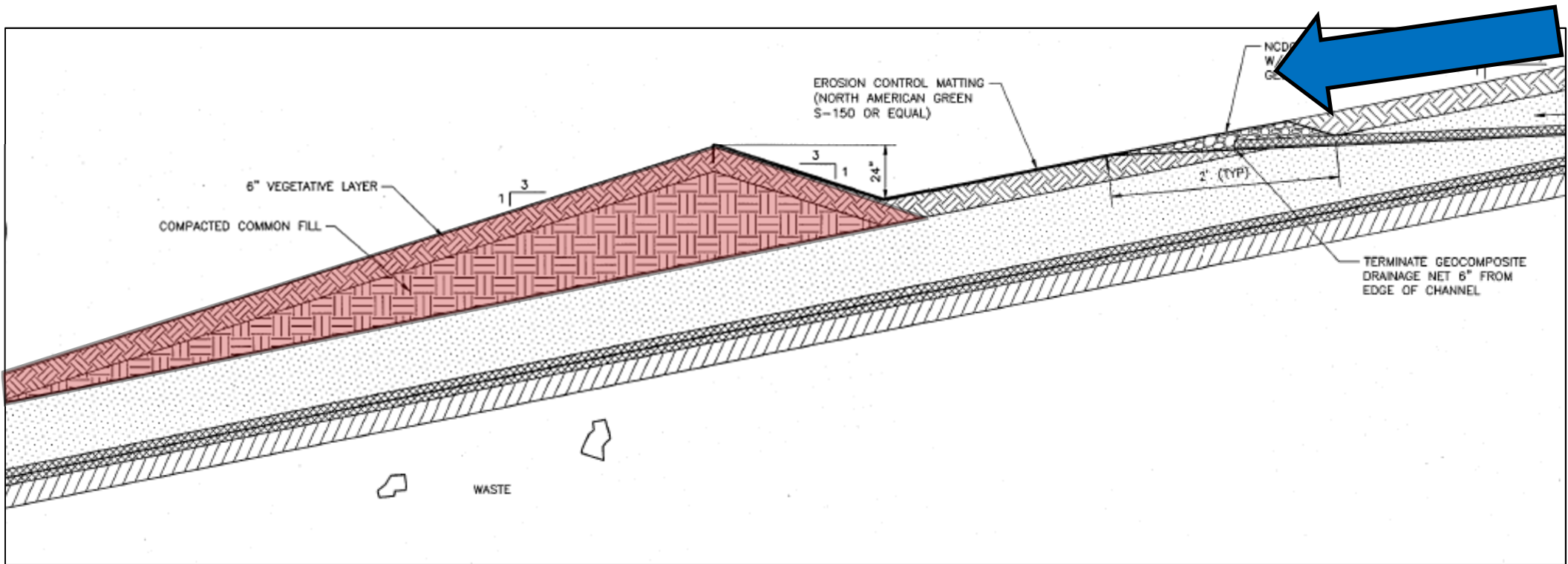


Design Drivers

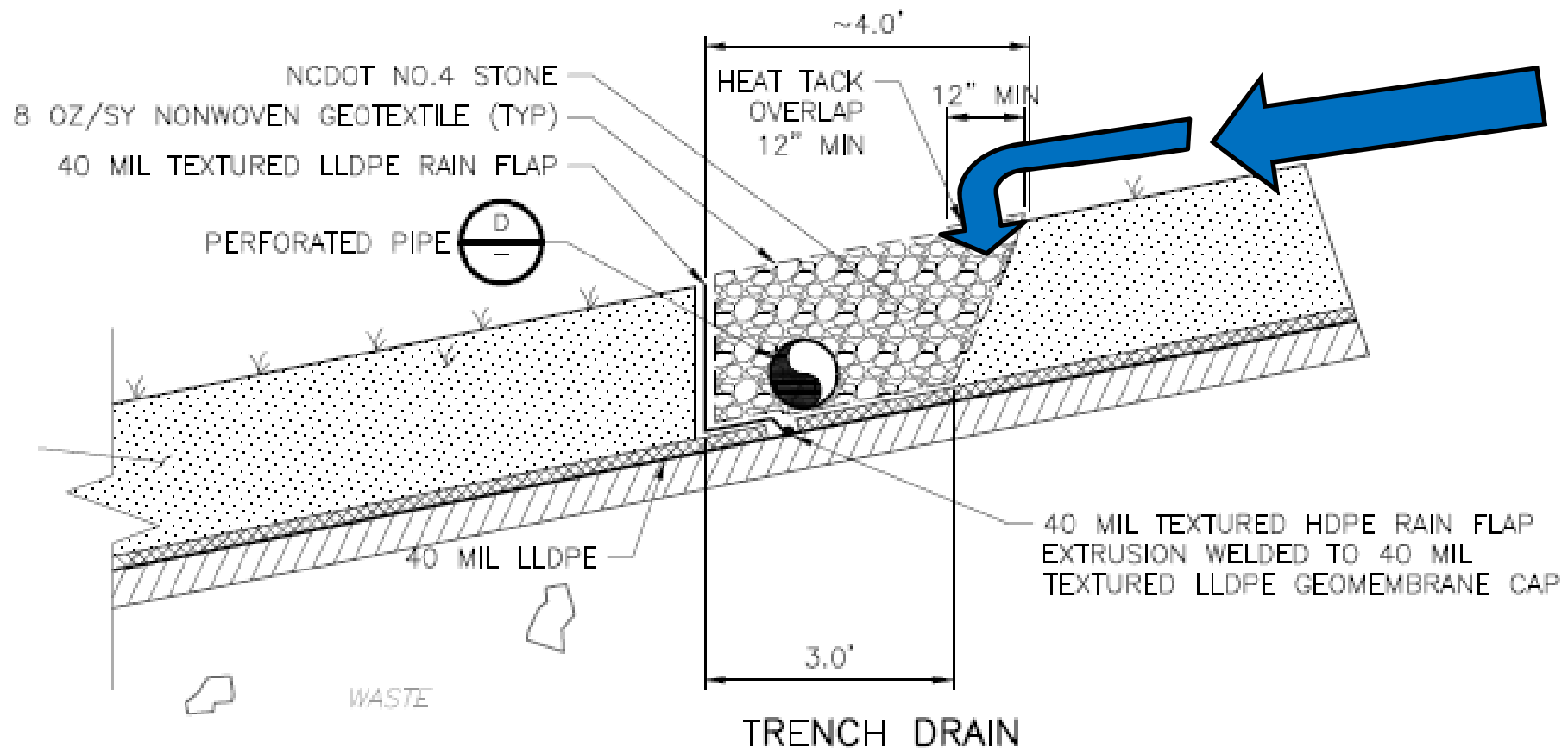
- Stormwater approach
- Phased construction
- Use of on-site soils



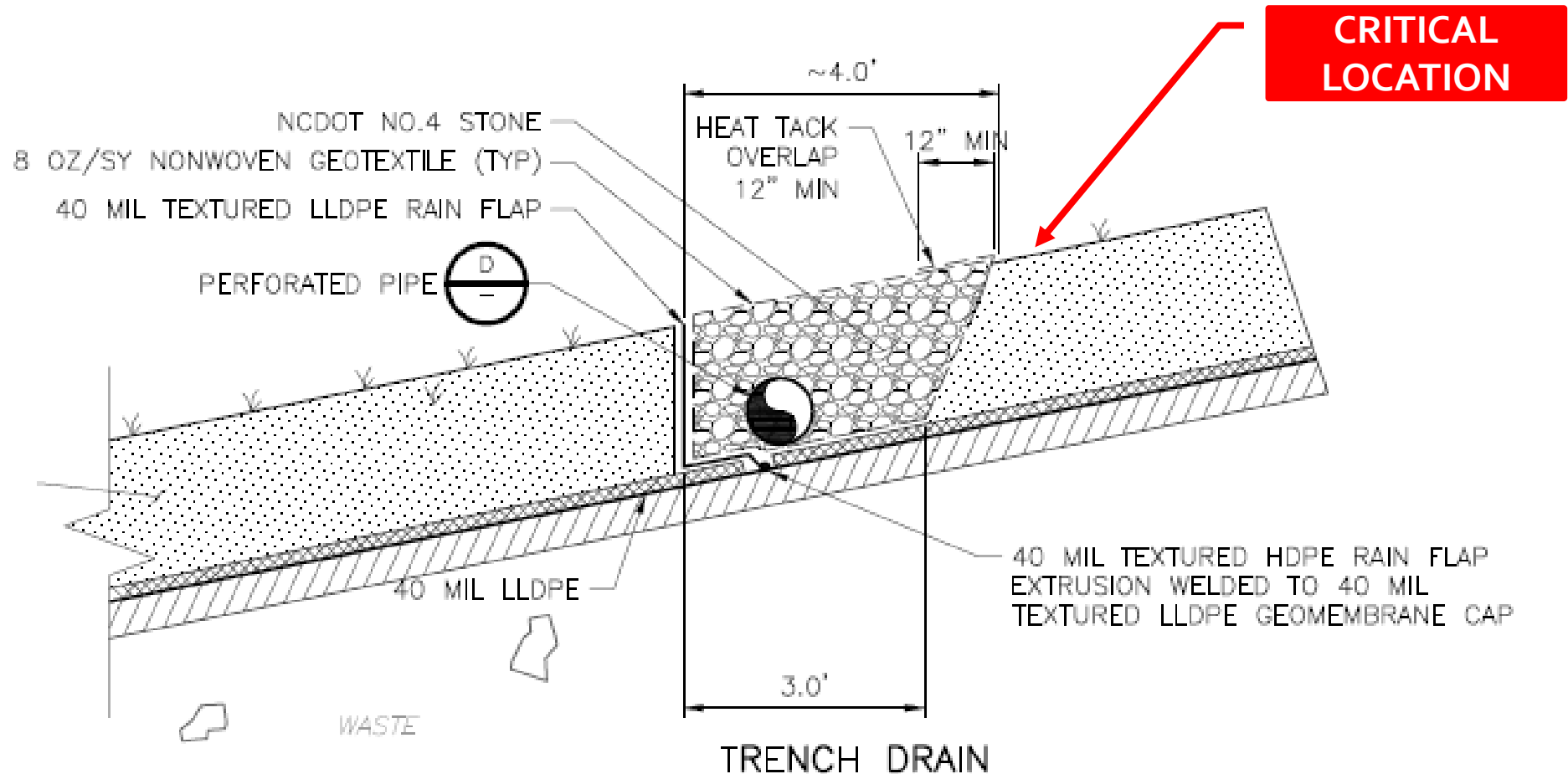
Stormwater Approach - Berms



Stormwater Approach - Bermless



Stormwater Approach - Bermless

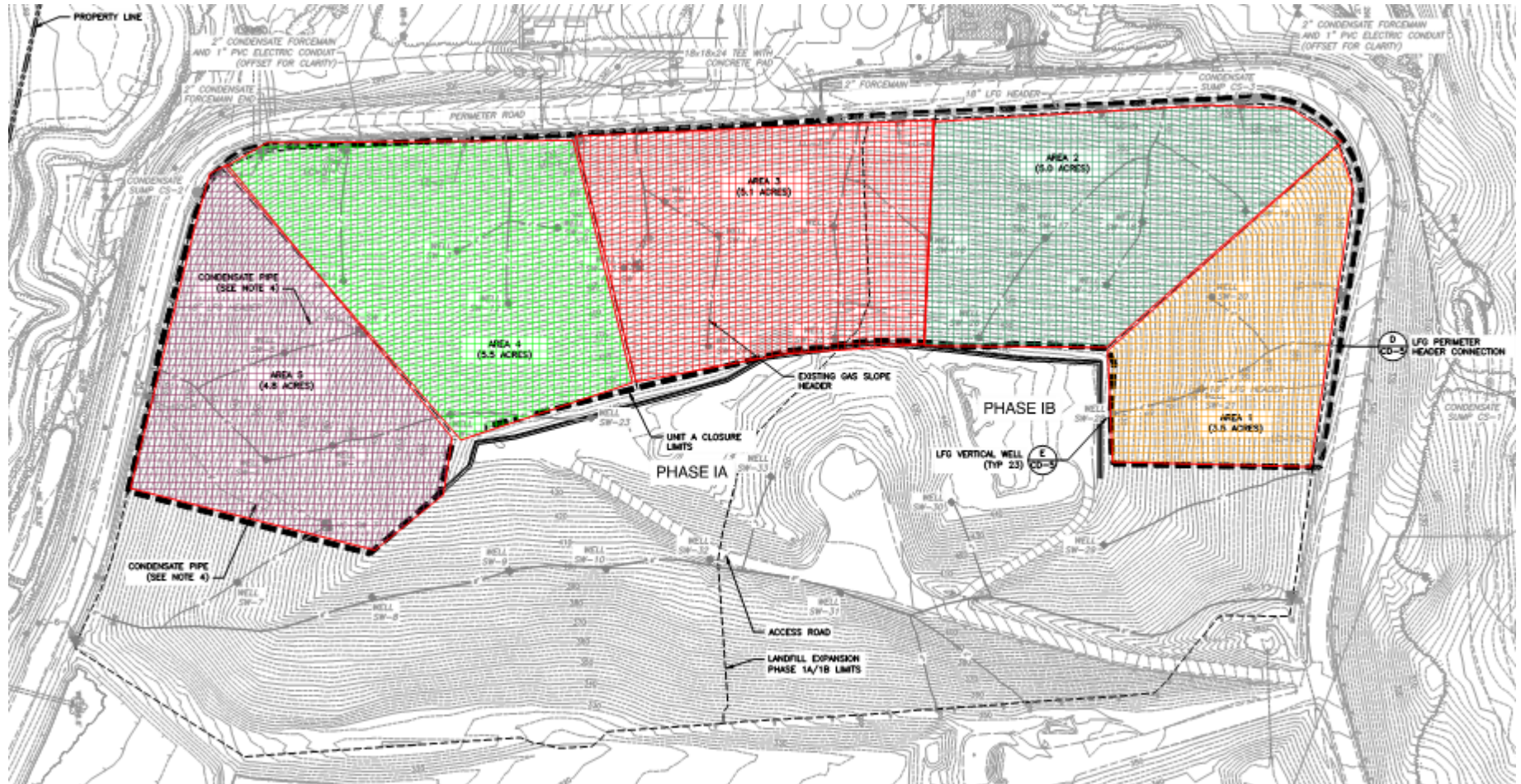


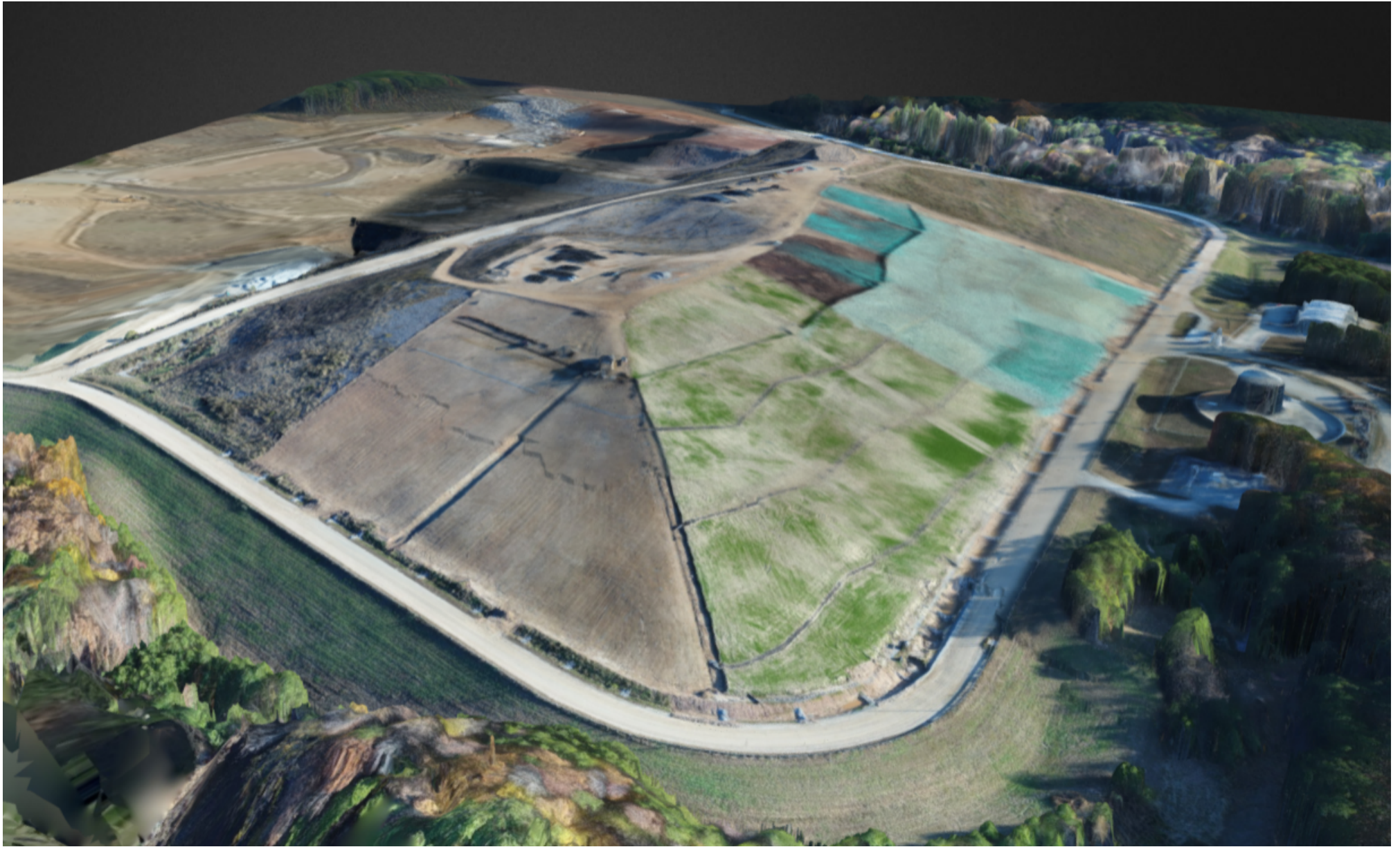
Design Criteria

- Minimize soil and seed loss
- Protect the rock



Phased Construction





Design Criteria

- Minimize soil and seed loss
- Protect the rock
- Identifying year round stabilization



On-site Soils

- Control costs
- Characteristics varied



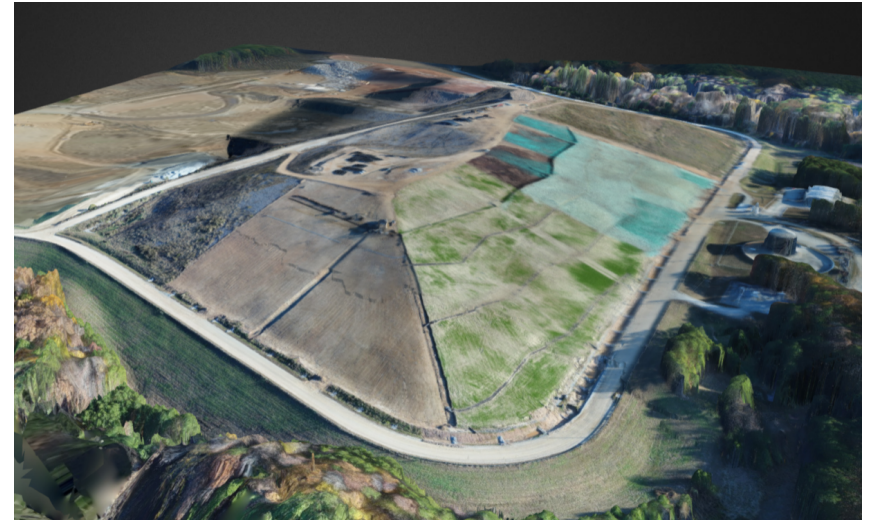
Design Criteria

- Minimize soil and seed loss
- Protect the rock
- Identifying year round stabilization
- Poor soils



Critical Success Factors

- Minimize soil/seed loss
- Quick stabilization
- Protect infrastructure (rock)
- Growth in a variety of seasons
- Amend poor soils

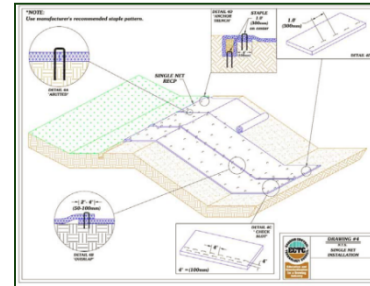


5 Fundamentals to Successful Stabilization

- Understand Your Substrate
- Pick the Right Plant Species
- Select the Right Erosion Control Material
- Ensure Proper Installation
- Conduct Inspection and Maintenance Activities



$$A = R \times K \times LS \times C \times P$$



Soil Testing

- Typically topsoil is applied - none available on-site
- Soil was available on-site
 - Would this material be suitable for use with an Engineered Soil Amendment to improve agronomics?
- 9 samples



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Soil Testing - Results

SOIL ANALYSIS RESULTS

Sample (#)	Texture (USDA)	Sand (%)	Silt (%)	Clay (%)	Soil pH (6.3 - 7.3)	TDS ¹ (ppm) (< 256)	SAR ² (< 2)	Organic Matter (%) (3 - 5%)	CEC % Sodium ⁴ (%) (< 2%)
1	Clay Loam	38.4	30.4	31.2	5.3	115.2	0.48	3.9	0.5
2	Loam	42.4	32.4	25.2	5.2	294.4	1.24	2	1
3	Clay Loam	24.4	44.4	31.2	4.6	89.6	0.53	1.8	0.3
(Optimum Plant Growth Conditions)									

Sample (#)	NO ₃ (lb/acre) ⁵	PO ₄ (lb/acre) ⁵	K (lb/acre) ⁵	Ca (lb/acre) ⁵	Mg (lb/acre) ⁵	Zn (lb/acre) ⁵	Mn (lb/acre) ⁵	Cu (lb/acre) ⁵	Fe (lb/acre) ⁵	B (lb/acre) ⁵	SO ₄ (lb/acre) ⁵
1	2.22	0.62	23.46	714	11.42	0.8	63.6	2.2	238.8	0.4	57.64
2	6.9	1.86	57.08	1372	44.24	0.6	18.2	1.6	113.8	0.2	195
3	10.04	0.62	10.95	184	9.24	0.4	25.2	1	70	0.2	6.72

Notes: 1. Total Dissolved Salts, 2. Sodium Absorption Ratio, 3. NeutraLime is also available in a liquid form, please contact a Profile representative with questions. 4. Sodium as % Base Saturation Cation Exchange Capacity (CEC), 5. lb/acre associated with a 6-inch depth.

Soil Testing - Results

SOIL ANALYSIS RESULTS

Sample (#)	Texture (USDA)	Sand (%)	Silt (%)	Clay (%)	Soil pH (6.3 - 7.3)	TDS ¹ (ppm) (< 256)	SAR ² (< 2)	Organic Matter (%) (3 - 5%)	CEC % Sodium ⁴ (%) (< 2%)
1	Sandy Loam	62.4	20.4	17.2	5.6	115.2	0.9	2.2	0.3
2	Sandy Loam	58.4	26.4	15.2	5.1	115.2	0.62	1.2	0.4
3	Sandy Loam	62.4	26.4	11.2	5.1	76.8	0.71	1.4	0.5
(Optimum Plant Growth Conditions)									

Sample (#)	NO ₃ (lb/acre) ⁵	PO ₄ (lb/acre) ⁵	K (lb/acre) ⁵	Ca (lb/acre) ⁵	Mg (lb/acre) ⁵	Zn (lb/acre) ⁵	Mn (lb/acre) ⁵	Cu (lb/acre) ⁵	Fe (lb/acre) ⁵	B (lb/acre) ⁵	SO ₄ (lb/acre) ⁵
1	9.34	3.08	38.32	1104	27.22	1	7.2	1.4	78.2	0.2	41.3
2	3.58	1.24	23.46	1272	15.56	0.6	17.8	1.2	128.4	0.2	27.86
3	5.04	1.44	28.15	1206	19.93	0.6	29.4	1.4	129.6	0.2	20.18

Notes: 1. Total Dissolved Salts, 2. Sodium Absorption Ratio, 3. NeutraLime is also available in a liquid form, please contact a Profile representative with questions. 4. Sodium as % Base Saturation Cation Exchange Capacity (CEC), 5. lb/acre associated with a 6-inch depth.

Soil Testing - Results

SOIL ANALYSIS RESULTS

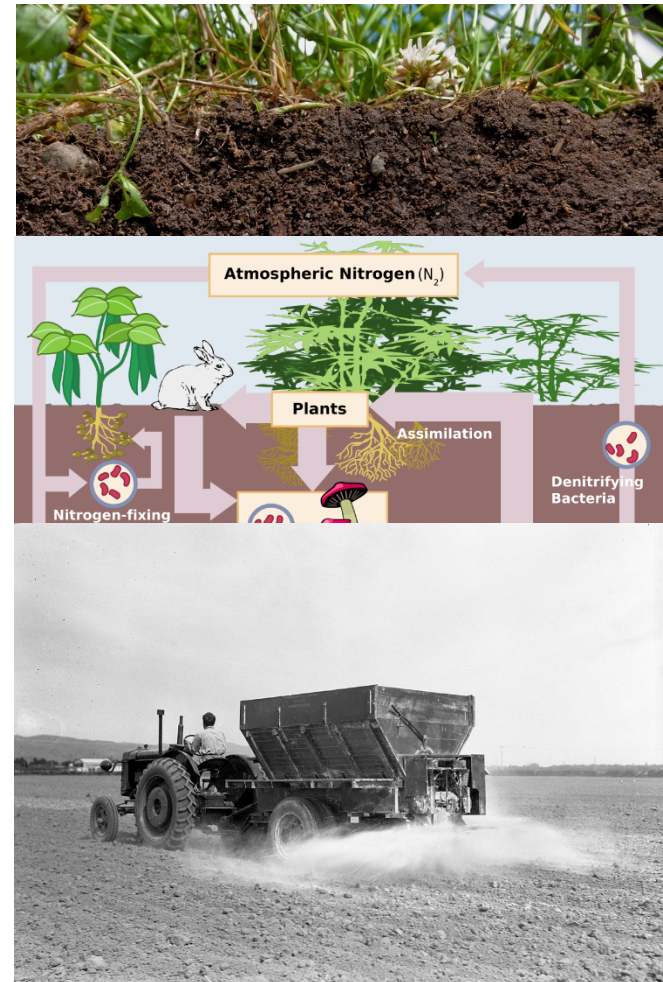
Sample (#)	Texture (USDA)	Sand (%)	Silt (%)	Clay (%)	Soil pH (6.3 - 7.3)	TDS ¹ (ppm) (< 256)	SAR ² (< 2)	Organic Matter (%) (3 - 5%)	CEC % Sodium ⁴ (%) ($< 2\%$)
1	Sandy Loam	54.4	34.4	11.2	5.1	57.6	0.59	1.6	0.5
2	Sandy Loam	62.4	20.4	17.2	4.9	224	0.79	1.9	0.2
3	Sandy Loam	54.4	26.4	19.2	5.3	76.8	0.43	1.7	0.5
(Optimum Plant Growth Conditions)									

Sample (#)	NO ₃ (lb/acre) ⁵	PO ₄ (lb/acre) ⁵	K (lb/acre) ⁵	Ca (lb/acre) ⁵	Mg (lb/acre) ⁵	Zn (lb/acre) ⁵	Mn (lb/acre) ⁵	Cu (lb/acre) ⁵	Fe (lb/acre) ⁵	B (lb/acre) ⁵	SO ₄ (lb/acre) ⁵
1	4.32	0.82	15.64	312	11.18	0.8	19	1.2	30.8	0.2	0.96
2	17.24	0.42	32.84	716	22.85	0.8	36.8	1.6	772	0.8	48.04
3	5.52	0.2	14.08	692	8.02	1	99.4	1.4	220.2	0.4	4.8

Notes: 1. Total Dissolved Salts, 2. Sodium Absorption Ratio, 3. Neutral Lime is also available in a liquid form, please contact a Profile representative with questions. 4. Sodium as % Base Saturation Cation Exchange Capacity (CEC), 5. lb/acre associated with a 6-inch depth.

Soil Testing – Amendment Selection

- Organic Deficiency
 - Biotic Soil Media
 - Biostimulants
- Nutrient Deficiency
 - N-P-K Fertilizer
 - Lime Material
- pH Imbalance
 - Lime Material



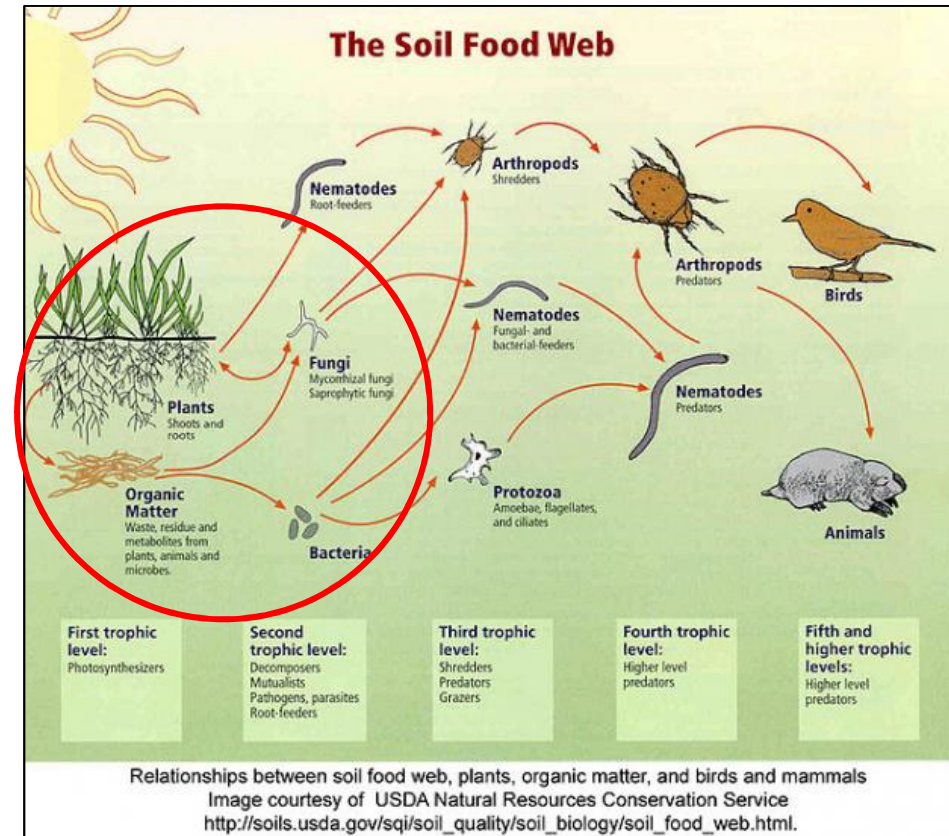
Soil Testing – Organic Deficiency

- Biotic Soil Media
- Biostimulants

Aqua-pHix™ (gal/acre)	NeutraLime™ ³ (lb/acre)	JumpStart™ (gal/acre)	BioPrime™ (lb/acre)	Soluble Gypsum (lb/acre)	ProGanics™ BSM (lb/acre)
0	80	2.5	80	0	4000

Biotic Soil Media

- Biotic Soil Media (BSM) is designed to accelerate development of soils.
- BSM improves the soil profile and composition by adding organic matter, biostimulants and soil building components to create a more favorable growing environment.



Soil Testing – Nutrient Deficiency

- N-P-K Fertilizer
 - Balanced “Triple 19” applied with BSM
- Lime Material - adds Calcium
 - Micronized Lime – applied with BSM
 - Agricultural Lime – Incorporated to a 6-inch depth

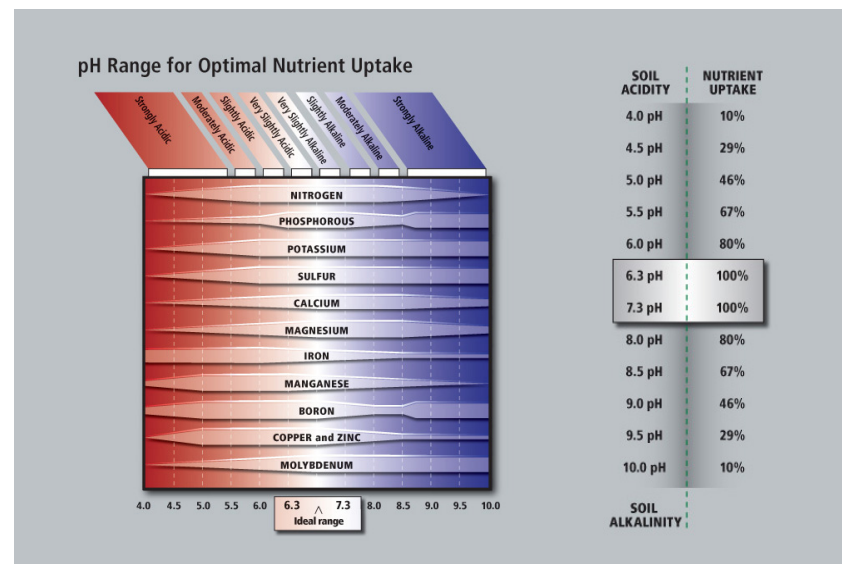
19-19-19

GUARANTEED ANALYSIS

TOTAL NITROGEN (N).....	19.00%
7.30% Ammoniacal Nitrogen	
11.70% Urea Nitrogen	
AVAILABLE PHOSPHATE (P ₂ O ₅)	19.00%
SOLUBLE POTASH (K ₂ O)	19.00%
DERIVED FROM: Urea, Ammonium Phosphate, Muriate of Potash.	
CHLORINE (Cl) Max.....	15.00%

Soil Testing – pH Imbalance

- Fast-Acting soil pH Modifier – NeutraLime™ Dry
 - 80 lb/acre applied with BSM
- Agricultural Lime
 - 6,500 lb/acre incorporated to a depth of 6 inches
 - Based on 100% Calcium Carbonate Equivalence (CCE)



Soil Testing – Amendment Specification

3.01 ADDITIONAL AMENDMENTS

A. All of the amendments in this section must be applied prior to the BSM installation.

1. Agricultural Limestone with a Calcium Carbonate Equivalency (CCE) rating of 100% shall be topically applied to the site at a rate of 6,500 lb/acre and disked into the substrate to a depth of 6 inches.
 - i. Agricultural Limestone may be utilized if the CCE is less than 100% however the Application rate must be changed accordingly to equal the same neutralizing effectiveness.
 1. In Example: 80% CCE Agricultural Limestone would have to be applied at approximately 8,125 lb/acre ($6,500/0.80$)

B. All of the amendments in this section must be incorporated in the hydraulic application of BSM.

1. Long-Term Soil Bio-Stimulant shall be BioPrime™ by PROFILE® Products LLC, or approved equal, and be applied at a rate of 80 lb/acre, and have the following composition:
 - i. Materials: Cold water processed Ascophyllum nodosum (seaweed extract), Humic Acid, Slow-Release Nitrogen source and Endo-Mycorrhizal spores
2. Fast-Acting Soil Bio-Stimulant shall be JumpStart™ by PROFILE® Products LLC, or approved equal, and be applied at a rate of 2.5 gallons/acre, and have the following component characteristics:
 - i. Materials: Beneficial soil bacteria, Humic Acid, and Soil Penetrants
3. Fast-Acting soil neutralizer shall be NeutraLime™ Dry by PROFILE® Products LLC, or approved equal, and be applied at a rate of 80 lb/acre, and have the following composition:
 - i. Calcium Carbonate content - $\geq 97.8\%$
 - ii. % Passing #35 Mesh Sieve - 100%
4. Fertilizer with a Guaranteed N-P-K Analysis of 19-19-19 shall be applied at a rate of 500 lb/acre.

Vegetation Selection

- Project Located in the Transition Zone of the U.S.
 - Blend of Cool and Warm-Season Species
- Hardy, low maintenance grasses to form a dense vegetative cover
- Nitrogen Fixing species for long term source of N
- Seeding will occur at various times throughout the year



Vegetation Selection

3.02 VEGETATION SPECIES SELECTION

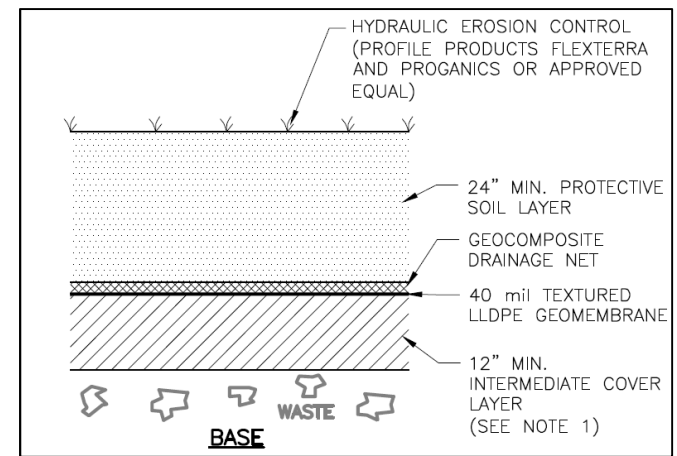
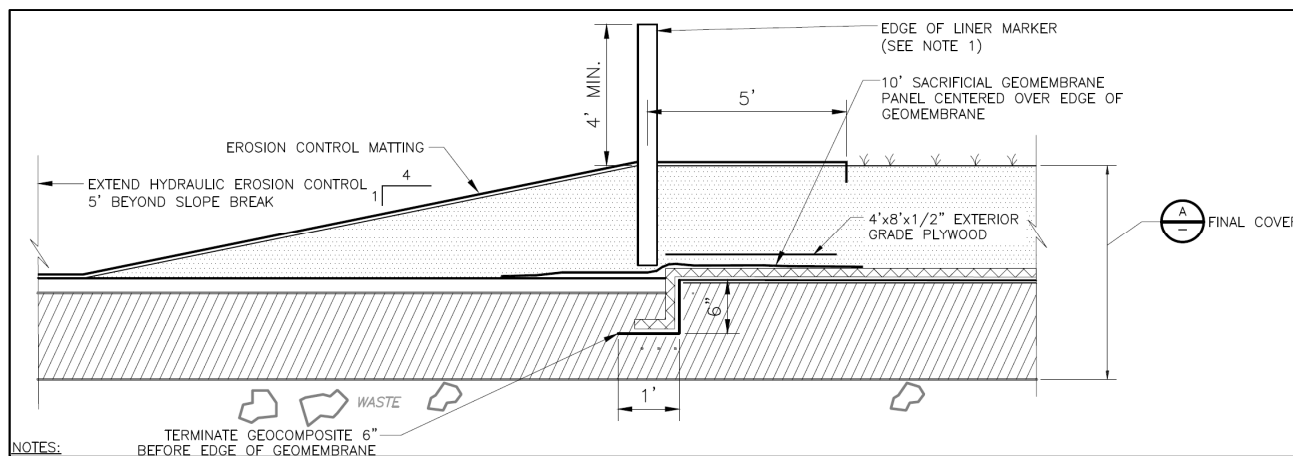
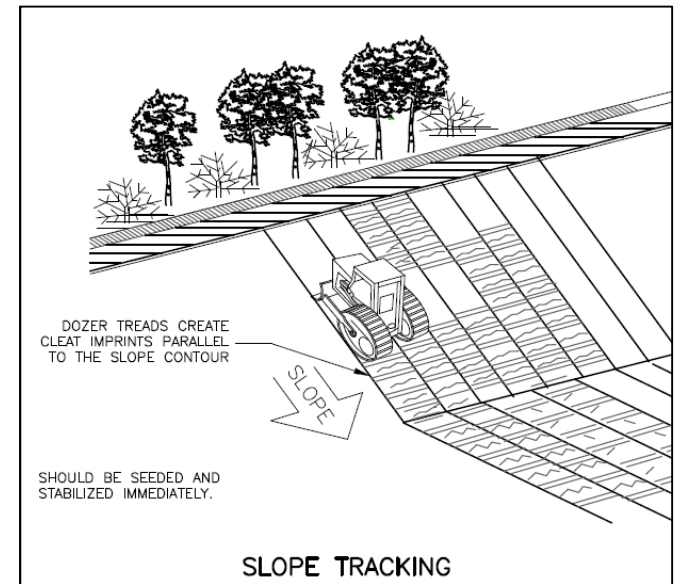
A. Vegetative Species and Application rates shall vary based on annual time of seeding. Listed below are the dates, vegetative species, and application rates in Pure Live Seed (PLS) of each species

1. March 1 – August 31
 - i. KY-31 Tall Fescue - 50 lb/acre of PLS
 - ii. Pensacola Bahia - 15 lb/acre of PLS
 - iii. Hulled Bermudagrass - 15 lb/acre of PLS
 - iv. Medium Red Clover - 10 lb/acre of PLS
 - v. German Millet - 10 lb/acre of PLS
2. September 1 – February 28
 - i. KY-31 Tall Fescue - 50 lb/acre of PLS
 - ii. Pensacola Bahia - 15 lb/acre of PLS
 - iii. Unhulled Bermudagrass - 21 lb/acre of PLS
 - iv. Medium Red Clover - 10 lb/acre of PLS
 - v. Annual Ryegrass - 10 lb/acre of PLS

B. The proper seed mix, dependent on date of installation, shall be incorporated into the BSM Application.

Erosion Control Selection

- Max. Slope Gradient 3H:1V
- Slope Lengths up to 150 ft
- Slopes to be Cat-Tracker
- Flexterra HP-FGM or Approved Equivalent Selected

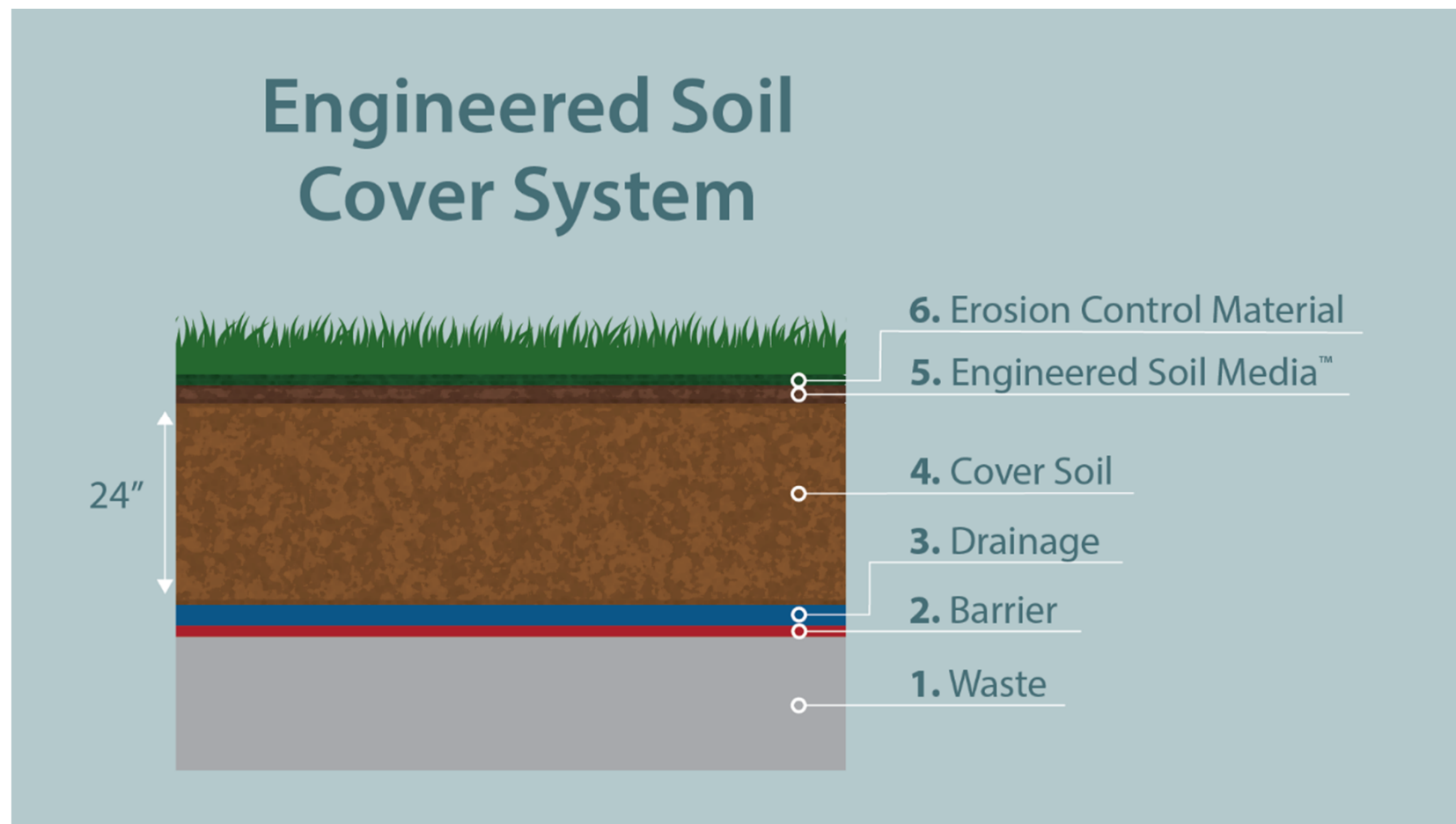


Traditional Cover System

Standard design is 18" cover soil and ~6" topsoil



Updated Cover System



Stabilization Schedule

Area 3: Nov. 2017 - 4 AC

Area 4: Apr. 2018 - 4.4 AC

Area 5: May 2018 - 4.3 AC



Updated Landfill Cover – Oct 2017



Updated Landfill Cover – Nov 2017



Updated Landfill Cover – Aug 2018



Updated Landfill Cover – Aug 2019



Updated Landfill Cover – Aug 2019



Tracking Soil Health – Aug 2019

SOIL ANALYSIS RESULTS (Optimal Plant Growth Conditions)											
Sample	Nitrate N ppm	Phosphorus ppm	Potassium ppm	Magnesium ppm	Calcium ppm	Sulfur ppm	Zinc ppm	Manganese ppm	Copper ppm	Iron ppm	Boron ppm
1	1	5	85	188	1057	3	0.55	4	0.6	37.2	0.3
	(10 - 30)	IF pH ≤ 7.1 (20-40) IF pH > 7.1 (10-25)	(150 - 250)	(60 - 300)	(≥ 400)	(5 - 20)	(1.3 - 3.0)	(4.1 - 12.0)	(1.0 - 2.0)	(7.1 - 20.0)	(< 2.0)

Sample	% Organic Matter	Soil Respiration mg CO ₂ /kg soil/week ⁵	Sand %	Silt %	Clay %	Texture USDA
1	4.6	1692.6	54.4	38.4	7.2	Sandy Loam
	(> 5%)	(> 1,000)	(20 - 60%)	Silt & Clay (40 - 80%)		

Notes: 5. Soil Respiration ppm = mg/kg

Sample							Bulk Density	
	Soil pH ⁶	Buffer Index	TDS ⁷	Soluble Salts mmhos/cm	Sodium ppm	SAR ⁸	g/cm ³	oz/in ³
1	6	7	76.8	0.14	11	0.39	1.04	0.6
	(6.3 - 7.3)		(< 256)	(< 0.75)		(< 2)		

Notes: 6. Contact Tech@profileproducts.com if pH is < 4.2 or > 9.2 for specific site recommendation. 7. Total Dissolved Salts. 8. Sodium Adsorption Ratio.

Sample	Cation Exchange Capacity: Actual % of Total CEC						Saturated Paste Extract Results				
	% K	% Mg	% Ca	% Na	% H	Total CEC	Bicarbonate ppm	Chloride ppm	Silicon ppm	SO ₄ ppm	Zinc ppm
1	2.4	17.5	58.9	0.5	20.6	9	33.6	12.3	22.2	9.6	0
	(3 - 7%)	(15 - 20%)	(65 - 75%)	(0 - 4%)	(0 - 5%)	(10 - 30)					

Tracking Soil Health – Aug 2019

Parameter	Unit	2016	2019
Soil Classification	n/a	Sandy Loam	Sandy Loam
pH	n/a	4.6 - 5.6	6.0
Organic Matter	%	1.2 - 2.2	4.6
Iron (Fe)	ppm	30.8 - 772	37.2
Manganese (Mn)	ppm	7.2 - 99.4	4.0

Conclusions

- Success in demanding environments
- Being receptive to technologies





Questions

For additional questions or information contact:

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